

RAFFLES INSTITUTION

**2023 Year 6 Preliminary Exam** Higher 2

# BIOLOGY

### 9744/01

Paper 1 Multiple Choice

28<sup>th</sup> Sept 2023

1 hour

Additional Materials: Multiple Choice Answer Sheet

### READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name and shade your Index Number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions in this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C**, and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

#### Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet. The use of an approved scientific calculator is expected, where appropriate.

(Erase all mistakes completely. Do not bend or fold the OMR Answer Sheet).

This document consists of **21** printed pages.



Raffles Institution Internal Examination 1. The diagrams below show the results of an investigation into the composition of different mixtures of amino acids. Each mixture of amino acids was separated using chromatography. Each chromatogram was then turned 90° and the amino acids were separated again by electrophoresis.

Which diagram shows an amino acid mixture in which the solubility of some of the amino acids is the same but the charge on those particular amino acids is different?



2. The enzyme invertase catalyses the breakdown of sucrose to glucose and fructose.

Three different enzyme inhibitors of invertase, X, Y and Z were investigated. The percentage inhibition of invertase was measured at different concentrations of inhibitor.

The graph shows the results of the investigation.



What are valid conclusions based on the above results?

- 1 The higher the concentration of inhibitor X, the less sucrose is broken down.
- 2 The production of glucose and fructose when using inhibitor Y is higher than when using inhibitor Z.
- 3 The production of glucose and fructose at an inhibitor concentration of 2 arbitrary units is lower than at an inhibitor concentration of 4 arbitrary units, for all inhibitors.
- 4 X is the most effective inhibitor.

Α	4 only	В	1 and 4 only	С	2 and 3 only	D	1, 2 and 4 only
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**3.** The distribution of membranes in the organelles of three cell types, a prokaryotic cell, a liver cell and an enzyme-secreting cell from the stomach, was determined. For each organelle, the amount of membrane is expressed as a percentage of the total amount of membrane in the cell.

Which row of values best represents the membrane distribution in the three cell types?

#### PM : plasma membrane

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IMM : inner mitochondrial membrane
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rERM : rough endoplasmic reticulum membrane OMM : outer mitochondrial membrane

	prokaryotic cell			liver cell			stomach cell		
	PM	rERM	IMM	PM	rERM	IMM	PM	rERM	IMM
Α	99	0	0	35	7	28	60	16	4
В	99	0	0	35	7	28	60	4	16
С	52	12	36	60	7	28	35	4	16
D	52	12	36	60	28	7	35	4	16

**4.** The table below shows the concentrations of certain ions in sea water and in the cells of the marine alga *Halicystis ovalis*.

ion	concentration in sea water/ mmol dm <sup>-3</sup>	concentration in cell/ mmol dm <sup>-3</sup>	
Na⁺	488	257	
K⁺	12	337	
Cl	523	543	
Ca <sup>2+</sup>	12	2	
Mg <sup>2+</sup>	34	trace	

Which statement about the cells of *H. ovalis* is supported by the data?

- A Energy is required to move potassium ions into the cells.
- **B** *H. ovalis* cells use chloride ions in greater quantities than sodium ions.
- **C** Positively charged ions move into the cell more readily than negatively charged ions.
- D Sodium ions move out of the cell down their concentration gradient.

5. The diagram shows the section through the cell surface membrane of a typical cell.



When compared to the more fluid cell surface membrane of a phagocytic cell, a number of differences in the membrane composition can be observed.

Which is the most likely set of differences that will be observed in the phagocytic cell?

- **A** a complete absence of component **Q** and a higher proportion of component **P**
- **B** a higher proportion of component **S** and a higher proportion of component **T**
- **C** a lower proportion of component **V** and a higher proportion of component **U**
- **D** an increased distance across **R** and a higher proportion of component **V**

6. Many commercially produced bananas are triploid instead of diploid.



Which of the following statements are incorrect?

- 1 As a result of triploidy, chromosomes cannot pair up during meiosis.
- 2 As a result of triploidy, non-disjunction occurs.
- 3 Mitosis cannot occur in triploid plants.
- 4 Sexual reproduction occurs more rapidly in triploid plants.
- 5 In order for a triploid organism to form, two triploid gametes need to fuse.
- A 1 and 4 only
- B 2 and 3 only
- **C** 3, 4 and 5 only
- **D** 2, 3, 4 and 5 only

7. The diagram shows the cell cycle of a mammalian cell.



Checkpoints in the cell cycle of mammals prevent the cycle from continuing when mistakes are made or when DNA is damaged.

Four of the checkpoints are described below.

- 1 Mitosis is blocked if DNA replication is incomplete.
- 2 Anaphase is blocked if the attachment of chromatids to the spindle fibres is unsuccessful.
- 3 DNA replication is blocked if DNA is damaged.
- 4 DNA replication stops if damage to DNA has not been repaired.

In which phases of the cell cycle do these checkpoints occur?

	checkpoint					
	1 2 3 4					
Α	М	G1	S	G2		
В	G2	М	G1	S		
С	G2	S	G1	М		
D	S	М	G2	G1		

**8.** Bacteria were cultured in a medium containing heavy nitrogen (<sup>15</sup>N) until all the DNA was labelled. These bacteria were then grown in a medium containing only normal nitrogen (<sup>14</sup>N) for 5 generations. The percentage of <sup>14</sup>N DNA strands in each generation was estimated.

Which curve provides evidence that DNA replication is semi-conservative?



**9.** The diagram below shows a particular stage in protein synthesis in eukaryotes.



Which of the following statements is true of structures X and Y?

- **A** Structure X is double stranded whereas structure Y is single stranded.
- **B** There is hydrogen bond interaction between all the subunits of both structures X and Y.
- **C** The information on structure Y is used to synthesize structure X.
- **D** The coiling of structure Y is a direct result of the information on structure X.

**10.** The graph shows the proportion of a bacterial population of *Neisseria gonorrhoeae*, displaying resistance to the antibiotic tetracycline.



Which of the following can be deduced from this graph?

- 1 Bacteria with beneficial adaptations survive and pass on their genes.
- 2 Immunity to tetracycline is triggered by over-use of the antibiotic.
- 3 Genetic variation in this bacterial population is increasing.
- 4 The use of tetracycline inhibits the growth of antibiotic-resistant *N. gonorrhoeae*.
- A 1 only
- B 1 and 4 only
- C 2 and 3 only
- **D** 2 and 4 only
- **11.** The hepatitis C virus is an enveloped, single-stranded positive RNA virus, which infects the liver cells of human beings.

Which of the following general strategies describes how the virus enters the host cell?

- A uncoating of the viral capsid with the host cell membrane
- **B** injection of the whole virus into the host cell
- **C** fusion of the viral envelope with the host cell membrane
- **D** penetration of the viral capsid via budding

**12.** The black-legged tick (*Ixodes scapularis*) is an arthropod which sucks blood from humans and other mammals. It is encountered mainly in wooded and semi-wooded areas. Some ticks can be infected by the bacterium, *Borrelia burgdorferi*.

When a tick bites a human by puncturing the skin, the bacterium is often introduced, causing Lyme disease. Lyme disease is a public health problem in North America and if left untreated, can cause important neurological impairment.

The diagram represents the two-year life cycle of a tick.



Which of the following statement(s) is/are true?

- 1 Ticks are classified under the domain Eukaryota.
- 2 Antibiotics can be used to treat Lyme disease.
- 3 The use of protective clothing by humans could prevent the spread of Lyme disease.
- A 1 only
- B 2 only
- **C** 1 and 3 only
- D all of the above

**13.** A mero-diploid is a haploid organism that is diploid for a small region of the chromosome, i.e. a partial diploid.

For example, a mero-diploid bacterium can have one I<sup>-</sup> repressor gene in one *lac* operon and one I<sup>+</sup> repressor gene in the other *lac* operon.

 $\mathsf{I}^{\scriptscriptstyle +}$  is the wild type while  $\mathsf{I}^{\scriptscriptstyle -}$  is a mutant which produces a repressor that does not bind to the operator.

	<i>lac</i> operon 1	<i>lac</i> operon 2		
Q	I <sup>+</sup> + P + O <sup>+</sup> + Z <sup>+</sup> + Y <sup>+</sup> + A <sup>+</sup>	I <sup>+</sup> + P + O <sup>+</sup> + Z <sup>+</sup> + Y <sup>+</sup> + A <sup>+</sup>		
R	$I^{+} + P + O^{C} + Z^{+} + Y^{+} + A^{+}$	I <sup>+</sup> + P + O <sup>+</sup> + Z <sup>+</sup> + Y <sup>+</sup> + A <sup>+</sup>		
S	I <sup>s</sup> + P + O <sup>+</sup> + Z <sup>+</sup> + Y <sup>+</sup> + A <sup>+</sup>	I <sup>+</sup> + P + O <sup>+</sup> + Z <sup>+</sup> + Y <sup>+</sup> + A <sup>+</sup>		
Т	I <sup>+</sup> + P + O <sup>+</sup> + Z <sup>+</sup> + Y <sup>+</sup> + A <sup>+</sup>	- + P + O <sup>+</sup> + Z <sup>+</sup> + Y <sup>+</sup> + A <sup>+</sup>		

4 different mero-diploids, Q, R, S and T were investigated.

- I<sup>+</sup>, O<sup>+</sup>, Z<sup>+</sup>, Y<sup>+</sup> and A<sup>+</sup> are DNA sequences in the operon which have completely normal activity.
- I<sup>-</sup>, Z<sup>-</sup>, Y<sup>-</sup> and A<sup>-</sup> are DNA sequences in the operon with mutations that result in complete loss of normal activity.
- P represents a normal promoter.
- O<sup>c</sup> is a mutation specific on the operator region which will always prevent the binding of repressor protein to the operator region.
- I<sup>s</sup> is a mutation specific to the repressor-coding gene which when expressed, produces a special repressor protein, which can still bind to the operator but not to lactose.

Which of the following statement(s) is/are incorrect?

- 1 For the *lac* operon, the capability of the repressor to bind to the operator region and prevent the transcription of structural genes depends on the conformation of the repressor protein and the operator.
- 2 In the presence of lactose, expression of the *lac* operon is possible in all of the above mero-diploid bacteria, **Q**, **R**, **S** and **T**.
- 3 **R** is the mero-diploid in which one of the *lac* operons will be constitutively turned on.
- A 1 only
- **B** 1 and 2 only
- C 2 and 3 only
- **D** None of the above

- **14.** All of the following statements about viruses are true except:
  - A The genome of RNA viruses are more likely to mutate than those of DNA viruses.
  - **B** All viruses produce RNA as an intermediate molecule during the production of new viruses.
  - **C** All RNA viruses produce DNA as an intermediate molecule during the production of new RNA viruses.
  - **D** Before entering a host cell, specific proteins of viruses bind to receptors on specific host cells.
- **15.** The ends of a eukaryotic chromosome contain a special sequence of DNA called a telomere.

Human telomeres consist of repeating TTAGGG sequences which extend from the ends of the chromosomal DNA. When cells undergo mitotic division, some of these repeating sequences are lost. This results in a shortening of the telomeric DNA.

The diagram shows a eukaryotic chromosome.



What is a consequence of the loss of repeating DNA sequences from the telomeres?

- 1 The cell will begin the synthesis of different proteins.
- 2 The cell will begin to differentiate as a result of the altered DNA.
- 3 The number of mitotic divisions the cell can make will be limited.
- 4 The production of mRNA will be reduced.
- A 1 and 2 only
- **B** 2 and 3 only
- **C** 1 and 4 only
- D 3 only

**16** There are different alleles of genes that code for enzymes that detoxify carcinogens. An individual's genotype for these alleles affects their chance of suffering DNA damage that might lead to cancer.

The figure below compares the frequency in the population of two alleles for hereditary cancer (*RB* and *BRCA 1*) and two alleles for detoxification enzymes (*NAT* and *GSTM 1*), and the increased risk of cancer each represents.



As research funds are limited, priority for research is given to the alleles that have the greatest possible impact on society.

To estimate the possible impact, the frequency of a cancer-promoting allele in population is multiplied by the increased cancer risk.

Based on the information above, which of the following statement(s) is/are valid in prioritising which alleles to focus research on?

- 1 Research on *RB* should be prioritised over *BRCA 1* as it causes a higher risk of cancer for those who possess *RB* alleles.
- 2 *GSTM 1* allele research should be prioritised over *NAT* as it has higher allele frequency in the population.
- 3 BRCA 1 is a tumour suppressor gene and prioritising it would save lives.
- 4 *BRCA1 and NAT* should be prioritised (over *GSTM 1* and *RB*) as they have the largest possible impact on society.
- A 1 and 2 only
- **B** 2 and 3 only
- C 3 and 4 only
- **D** 4 only

**17.** The figure shows the process of chromatin modification prior to transcription.



With reference to the figure above, which of the following statements regarding chromatin modification is correct?

- A Chromatin modification complexes result in the reversible acetylation or deacetylation of DNA.
- **B** TAP binding results in the immediate downregulation of transcription.
- **C** The binding of TAP and TBP to their binding sites is dependent on the recognition of histone tails.
- **D** In the active conformation of chromatin, the repositioning of nucleosomes allows for the exposure of TAP and TBP binding sites, leading to protein binding.

**18.** Plants produce carbon dioxide during respiration and use carbon dioxide during photosynthesis. The graph shows the net volume of carbon dioxide taken up in plant cells at different light intensities.



What is shown by the graph?

- **A** There is no photosynthesis between W and X.
- **B** There is no photosynthesis between Y and Z.
- **C** There is more respiration than photosynthesis between Y and Z.
- **D** There is more respiration than photosynthesis between W and X.

**19.** The diagram shows the path taken by electrons and the formation of hydrogen ions in the light-dependent stages of photosynthesis.



Which of the following statement(s) is/are true?

- 1 P is photosystem I and Q is photosystem II.
- 2 R is oxygen, a product of photolysis.
- 3 In the absence of light, the processes in the diagram do not take place.
- 4 Electrons and protons at the end of these processes are used to produce reduced NADP from NADP.
- A 3 only
- **B** 4 only
- **C** 2, 3 and 4 only
- **D** all of the above

20. Colour blindness is controlled by a gene on the X chromosome. The allele for colour blindness, X<sup>b</sup>, is recessive to the allele for normal colour vision, X<sup>B</sup>. The gene controlling the presence of a white streak in the hair is not sex-linked, with the allele for the presence of a white streak, H, being dominant to the allele for the absence of a white streak, h.

The diagram shows a pedigree in which some of the individuals may or may not have colour blindness and may or may not have a white streak present in the hair.



What is the probability that individual 8 is a male with the same phenotype as individual 7?

- **A** 0.125
- **B** 0.25
- **C** 0.5
- **D** 0.75
- **21.** Which of the following is not a consequence of increased cellular levels of cAMP when glucagon binds to its specific receptor in the liver cell?
  - **A** activation of a kinase cascade
  - **B** activation of adenylyl cyclase
  - **C** increased phosphorylation of glycogen phosphorylase
  - D inhibition of glycogen synthesis

**22.** Cystic fibrosis is a recessive disease commonly caused by a mutant allele with a 3-base deletion.

A couple who are carriers for this condition have 2 children (m and n). One of their offspring is normal, the other suffers from cystic fibrosis. DNA of 2 children (m and n) are extracted and separated by electrophoresis.

Which of the following shows the correct banding patterns of m and n?



negative plate (cathode)

**23.** Patients with type I diabetes cannot produce the hormone insulin. Injections of commercially produced insulin are used to treat symptoms of this form of diabetes. The data shown below was collected during an investigation comparing two insulin therapy medicines, Glargine and NPH.



End of observation period

What conclusion can be drawn from the graphs regarding the two insulin therapy medicines?

- A NPH insulin is more efficient in maintaining a homeostatic blood glucose level over a 17-hour period after injection.
- **B** NPH insulin and Glargine insulin have similar effects on the rate of movement of glucose out of the blood stream into cells.
- **C** The rate of glucose uptake into cells in the presence of Glargine insulin remains constant for more than 17 hours after injection.
- **D** NPH insulin stimulates the rate of insulin production by the pancreatic beta cells.

- 24. Which processes are promoted by the hormones insulin and glucagon?
  - 1 conversion of glycogen to glucose in liver cells
  - 2 respiration of glucose in liver cells
  - 3 uptake of glucose by muscle cells
  - 4 release of glucose in urine

	insulin	glucagon		
Α	1	2		
В	2	4		
С	3	1		
D	4	3		

- 25. Which statement(s) is/are correct interpretations of Darwinian evolutionary theory?
  - Advantageous behaviour acquired during the lifetime of an individual is likely to be inherited.
  - II In competition for survival, the more aggressive animals are more likely to survive.
  - III Species living in a stable environment will not evolve any further.
  - IV Variation between individuals of a species is essential for evolutionary change.
  - A I, II and IV
  - B II and III
  - C III and IV
  - **D** IV only
- **26.** Which statement provides the best evidence that all organisms descended from a single common ancestor?
  - A All eukaryotes have non-membrane-bound structures known as proteasomes.
  - **B** In organisms using the ubiquitin-proteasome mechanism, ATP hydrolysis is also required.
  - **C** The structural features of proteasomes are highly conserved in organisms of all kingdoms.
  - **D** The ubiquitin-proteasome mechanism is capable of breaking down a very diverse variety of proteins.

- 27. Which of the following statement(s) could describe both B-lymphocytes and T-lymphocytes?
  - 1 They contain specific protein receptors in their cell surface membranes.
  - 2 They differentiate into plasma cells.
  - 3 They divide by mitosis.
  - A 1 and 3 only
  - B 1 and 2 only
  - C 2 and 3 only
  - D 2 only
- **28.** In 1980, the World Health Organisation announced that the world was free from smallpox. This was the result of a campaign lasting over 20 years. The campaign relied upon the vaccination of at least 80% of the populations at risk of the disease, and careful surveillance was carried out to identify new cases rapidly.

The following statements are characteristic of the smallpox virus and its vaccine.

- 1 There are multiple strains of smallpox virus.
- 2 No booster jab required.
- 3 Vaccine is cheap.
- 4 Vaccine could be stored easily.
- 5 Few infected people are asymptomatic.
- 6 Human is the only host of smallpox virus.

Which of the following is / are not reason(s) for the success of the smallpox eradication?

- **A** 1, 2, 3, 6 only
- **B** 3, 5, 6 only
- **C** 1 only
- **D** 1, 2, 4, 5, 6 only

- **29.** Which of the following statements are true regarding the impact of climate change on freshwater supplies?
  - I decreased supply of groundwater due to increased demand from increasing human population
  - II decreased supply of groundwater due to drought
  - III groundwater contamination by nutrient runoff due to heavy rainfall
  - IV groundwater contamination by saltwater due to sea level rise
  - V destruction of water infrastructure such as dams and levees due to heavy rainfall
  - A II and IV only
  - B III and IV only
  - **C** II, III, IV, V only
  - **D** all of the above
- **30.** The diagram shows the potential dengue transmission in case of temperature rise.



Which of the following statements cannot be inferred from the diagram?

- **A** An increase in temperature will increase the dengue transmission rate.
- **B** The higher the temperature, the greater the impact on dengue transmission.
- **C** Dallas and Jacksonville have the highest dengue transmission because they are the warmest cities.
- **D** When temperature increases from +2°C to +4°C in Boston, the number of weeks of potential dengue transmission will double.



## Answers H2:

1.	В	11.	С	21.	В
2.	В	12.	D	22.	Α
3.	В	13.	D	23.	С
4.	Α	14.	С	24.	С
5.	С	15.	D	25.	D
6.	D	16.	D	26.	С
7.	В	17.	D	27.	Α
8.	Α	18.	D	28.	С
9.	D	19.	С	29.	С
10.	Α	20.	Α	30.	С